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SCIENCE IS ROOTED IN CONVERSATIONS

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First let me say what a pleasure it is to be meeting you all, and in the place where I spent so much time as a youngish fisheries scientist. I'm looking forward to the rest of this meeting, and thank Jean Collins and Joan Parker for inviting me.

My revised title[1], and my theme, come from the Memoirs of Werner Heisenberg, quoted by Neil Belton in his biography of Schrodinger, "A Game with Sharpened Knives". I shall talk about my needs for information in various stages of my scientific life in the hope that it might be of some use to you. Of course, it represents a sample of just one, and as a sort of amateur statistician I would be wary of drawing any conclusions from that. You have been warned!

When I arrived on the scene of my first job, in 1947, at the Fisheries Laboratory in Lowestoft, Suffolk, England, I was greeted by the then Director of the lab, Mr. Michael Graham with an oral outline of my main task and a scruffy blue envelope. He explained the nature of the problem: to come up with a theory of fishing that would be applicable at least to North Sea trawling, particularly for plaice and haddock. The writing on the envelope, he said, came from an RAF colleague, a mathematician/physicist, Mr. H. R. Hulme, who had written it while sitting with him on a tank turret in Normandy, plotting the statistical distributions of shells and bombs. It bore a short differential equation and a suggested integration of that. I said "But I know hardly any maths!". "Then go learn some" was the answer. So off I went to find 'Teach Yourself' books and, later, to a part-time course in statistics at University College, London, being offered to Civil Servants at His Majesty's expense. At the same time I was analyzing, with a colleague, Dick Margetts, the historical data that would demonstrate the expected recovery of the plaice stocks as a result of the "rest" given them by the restriction of North Sea fishing during the Second World War.

Note the two "Mr."s, plus my own making three. At that time few of us thought Ph Ds were worth having. Most were anxious to begin useful work. All of us then bore the title Naturalist. And most of us were influenced by the recently ended war: scientists should be useful, and many of us admired the contributions to the outcome of the conflict made by those scientists –mostly physicists, biologists and mathematicians - who had been engaged in "operational research" (Operations research, to the Americans).

[1] My original, rather obscure, title, "Scaling Fisheries", came from a book about the history of fisheries science by Timothy D. Smith.

What emerged from that second meeting, three years later (The first had been a pre-appointment interview, that had also involved the previous Director, E. S. Russell [2], in a tiny, dark and musty cubby-hole in the Ministry of Agriculture, Fisheries and Food, in Horseferry Road, Westminster), was the text of a book, written with my late colleague, Ray Beverton. It took His/Her Majesty's Stationery Office seven more years to publish it, but that's another story. But the relevance of that bit of history to this conference is that on my second or third day at Lowestoft I told my boss I would be spending some time in the library reading the literature on this subject, to which he replied: "Do the work first, then read 'the literature' to see whether anyone else got there first. Reading will only confuse and distract you. By the way, here are a couple of papers by some Americans who seem to have tried hard but I think got it a bit wrong. And here's a book I wrote during the war." – it was The Fish Gate.

The advice not to read the literature didn't worry me at the time. My education at Reading - a 'Red Brick' university as we used to call such newcomers to academia - was weighted more towards practice than literature reading, and my personal interest was really in solving puzzles without bothering whether someone else had solved them before me. Lowestoft had – and I think still has – a good general ecology and fisheries library, and I certainly read voraciously when I was there. But the papers and books that came to my attention and helped me in my task came mainly from colleagues, through contacts abroad via Graham, and by reading general periodicals such as Science and Nature.

Things changed when I came to FAO, here in Rome, in December 1953. My taskmaster here was then Dr Geoffrey Kesteven, an Australian, Chief of the Biology Branch of the Fisheries Division. His Branch then comprised four people, including him and myself. The idea that we were doing 'biology' was rather strange to me. In Lowestoft we were Naturalists; we all – including the Director - went to sea regularly and frequently, on both research ships and commercial vessels, thought of ourselves as partway to being fishermen (women were not allowed on the ships), and encouraged to think of ourselves as doing operations research, in the post-war fashion.

Anyway, my first task in FAO was to analyze a report by a Chinese consultant, Shao Wen Ling, a fine painter of prawns, about the sweet-water fisheries of the Mekong river system and the extraordinarily productive variable lake, Tonle Sap, and what French engineers under UN auspices were planning to do to them. So, back to the drawing board. My thesis at Reading had been on the anatomy of a European cyprinid, the tench (Tinca) but that didn't seem to be very relevant to the multi-species fresh- and brackish-water fisheries of Southeast Asia. So, now I really did have to seek out such literature as was available in the embryonic FAO library, and rather more in the Vatican and in the private library of an Italian (Roman) retired oceanographer and well-known gourmet, Professor

[2] Russell was the author of an influential book, "The Overfishing Problem", published during the war, in 1942. He had published his original contribution 11 years previously, in the context of ICES discussion of this problem

Giorgio Bini, whom Kesteven had befriended. Among other things Bini was the author of a six-volume treatise on the fishes of the Mediterranean
With my newfound expertise I concluded that the great plans for hydroelectric dams along the Mekong were not a good thing, at least not for the hundreds of thousands of families living from the biological productivity this great river-system.

Bini had spent his latest years – apart from collecting ancient armor, and cooking and eating – in compiling an annual Bibliografica Oceanografica. Kesteven's idea was that we would help him internationalize it, broaden its scope and publish it in English as well as in Italian. Bini was also much in arrears and we thought the value of the B.O. would be enormously enhanced if we could get it up to date and then keep it current. One week, I think in 1954 or '55, I went by train to Paris with Kesteven, Bini and two of his Italian colleagues. Our idea was to visit UNESCO and also talk to some French marine scientists. What I mainly remember of the trip was learning, on the train, how good was Valpolicella – a red wine of the Lake Garda region – a subject about which I was then entirely ignorant: and, from the Italians, how impossible it was to find anything decent to eat in Paris!

The environment in FAO at that time was conducive for a junior staff member to continue to exercise his professional skills, and I did a great deal of 'reading the literature' because a few of us were having to deal with a vast array of issues. We began our excursion into the realm of information rather than the solving of scientific and technical problems by becoming High Tech. We typed bibliographic references on cards that I designed, with punched holes and/or slots around their edges, sorted with knitting needles, we made multiple carbon copies of 3x5 note cards, and we invested in Flexiwriters, like the ticker-tape machines one sees in old American movies, and so noisy the operator had to work enclosed in a glass cabin. Titles were insufficiently informative, published abstracts too long to copy and also often not very informative, so we decided on annotations, continuing the system begun by Giorgio Bini. Kesteven thought that all the staff of the Branch should regularly contribute annotations, and to that end incoming publications were circulated throughout the Branch. This was onerous but did ensure that we all kept in touch with our disciplines and did not become complete bureaucrats or even aid-giving technocrats. This approach was familiar to me: like Graham's insistence that everyone spend time at sea.

Another technique introduced at the time involved punching small holes all over special cards, then holding batches of them up to the light to detect coincidences. This was of course a Lo-Tech version of the famous Hollerith/IBM punched cards that could be sorted electrically. The story of my later involvement with the latter remains vivid. A Committee of Three Scientists established in 1960 by the International Whaling Commission, chaired by Professor Douglas Chapman of the University of Washington, Seattle, had arranged for all existing biological data collected by scientists aboard whaling vessels in the Antarctic to be compiled on punched cards. Nearly two decades later, when the Scientific Committee of the IWC was engaged on what was rather

misleadingly called a Comprehensive Assessment of all whale stocks, Chapman was asked to retrieve the old cards. A year later he was asked to report back. He said that the cards had unfortunately been ruined by damp and nibbled by mice, but all was OK, he had found the holes in heaps on the floor!
But I digress. The development of a current periodic bibliography, and then the Current Contents in Aquatic Sciences and Fisheries,[3] led us to create related tools, such as a list of periodicals and their short names, publishers' addresses and so on, directories of research institutions and an associated list of marine scientists. Kesteven also had the idea of creating what we called Thesauruses: one for compilations of data on Species and Stocks of fishes, shellfishes etc (SAST), the other for information on Methods and Subjects (MAST). These evolved, respectively, into the long series of FAO Fisheries Technical Papers on species and species groups, and the Manuals on methods of stock assessment and the like, issued sequentially in the same series, as well as technical material in FAO Fisheries Circulars. I was interested to see that these series have now been supplemented by the attractive, smaller format FAO Technical Guidelines for Responsible Fisheries.

Our encyclopedic approach also spawned a series of comprehensive reviews of specific knowledge-areas of fisheries interest. These were a series of books on such matters a fishing vessel design; fishing gear design, construction and operation; aquaculture: shrimp and prawn fisheries and cultivation: marine pollution; and marine mammals – this last with UNEP. In each case the books were the outcome of world conferences on the subject, with hundreds of participants. But these were each prepared during one, two or even three years beforehand through consultations with as many specialists as we could persuade to cooperate, and conduct of a series of special "workshops". In all thousands of specialists contributed their knowledge and time.[4]

I should say that although our idea was to provide services to others we were driven by our own needs to plan, supervise and evaluate fisheries assistance projects, to conduct training courses and centers, and to participate constructively in the work of international

[3] The decision we made that the most appropriate mini-universe to map would be the envelope 'aquatic sciences and fisheries' was not an easy one, and several alternative definitions of the scope of our embryonic information services were considered. The final choice reflected out belief at the time that fisheries science and oceanography (or 'oceanology', and the Russians correctly insisted) were particularly closely related, as were marine science and limnology. It also reflected the fact that the Division, and hence such powers of decision as we had, were organized that way. And, finally, that we had developed fruitful working relations – in the days before the UNESCO Marine Sciences Division and the Intergovernmental Oceanographic Commission – with the very active Scientific Committee on Oceanic Research (SCOR) of the International Council of Scientific Unions (ICSU).

[4] Not all of these were primarily concerned with science, of course; the first two mentioned were mainly about naval, mechanical and systems engineering. In recognition of the relations of these professional disciplines with scientific research the Division of the Department of Fisheries of which I was for a time Director subsumed both the original Biology Branch and the Technology Branch except for the Section concerned with fish processing.

fisheries organizations, including the older bodies such as ICES, CIESM, ICNAF (now NAFO) and NEAFC, as well as the newer regional Commissions and Councils being established under the FAO umbrella, such as the GFCM and the IPFC[5] conservation.

From about 1960 to 1972 I was engaged essentially in administrative/ managerial/political stuff in FAO, UNESCO and the UN, but then returned to be engaged in the population dynamics of marine mammals, backed by the FAO and UNEP infrastructures and the human resources offered by membership of the Scientific Committee of the IWC). After my early retirement from the UN-System in 1980 I continued to do scientific work, but with little supporting infrastructure, although I was associated with, and partially financially supported by, a number of international non-governmental organizations (INGOs) campaigning on environmental and animal welfare issues[6], as well as with the environmental branches of some governments, especially of the Republic of Seychelles. In the first decade of the Third Millennium I have gradually moved back to a focus on broader issues of fisheries science (though still including marine mammals) and have had to work to bring myself up-to-date with what has happened in that field during the past two decades.[7] In doing that I should say that the FAO Fisheries Library and Jean Collins have been most helpful.

I have also discovered the joys and some of the sorrows of the Internet and the World Wide Web. Practicing science outside any institution, even working in Britain or Italy, and living on a pension of diminishing value, has some features in common with practicing in a so-called developing country. I am on e-mail, have a working computer and think twice about buying a newer one. I use the telephone sparingly and as yet do not have access to broadband. Printer cartridges and paper are costly, as is postage, and increasingly so relative to income. Travel to relevant meetings is also increasingly expensive and, with advancing age, physically more difficult. Subscriptions to scientific periodicals are now mostly beyond my means.

So where are the solutions to the communication and access problems posed by these realities? First, I should say that friendly or at least cordial personal contacts with other scientists are crucial. When I come across a reference to a paper that looks relevant and interesting my first thought is: who among my professional contacts is likely to have a copy of it and be able to find it and willing to go to the trouble and expense of sending it

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[5] International Council for the Exploration of the Sea; International Commission for the Scientific Exploration of the Mediterranean Sea; International Commission for the Northwest Atlantic Fisheries: North Atlantic Fisheries Organization; Northeast Atlantic Fisheries Commission: General Fisheries Council for the Mediterranean; IndoPacific Fisheries Council

[6] Especially The Threshold Foundation, World Wide Fund for Nature (WWF), Greenpeace International, the International Fund for Animal Welfare (IFAW), Friends of the Earth (FoE): Humane Society International (HIS) and the World Conservation Union (IUCN)

[7] One result of that exercise is in my "Foreword to the 2004 printing" of R. J. H. Beverton and S. J. Holt "On the Dynamics of Exploited Fish Populations"; 1957 (HMSO, London), 1993 (Chapman and Hall, London), 2004 (Blackburn Press, NJ, USA).

to me, as hard-copy or digitally? Clearly, to have a wide range of such friends, particularly well-organized ones, is an enormous advantage. Obviously, next best is friends who themselves have ready access to good local libraries.

Second, while ability to comfortably read the texts of papers is evidently important, the lists of references appended to them or in foot- or end-notes are often more important. Again and again I find that the paper I thought would be interesting is not, but its reference list leads me to something that is. In this connection I might say that the practice of some scientific periodicals, such as Science, in truncating the references – usually by omitting titles, and sometimes by failing to register both the first and the last page of articles is, to say the least, unhelpful. It makes it much more difficult to judge whether a reference might be useful, and to ask someone for it or to order it.

Third, creative science calls for what the Maltese philosopher, Edward de Bono, labeled 'lateral thinking', and on a broad scale. I mentioned that in the 1940s and '50s some of us thought of ourselves as being engaged in operations research in fisheries, rather than in the specific disciplines in which we were trained (Mine were zoology with also botany and chemistry). In the first couple of years engaged on my first research project I 'discovered' the theory of searching for submarines in the Atlantic (classified stuff then); the theory of games and economic behavior (Von Neumann and Morgenstern); cybernetics and servomechanisms (Norbert Weiner, A. Porter); mathematical applications to biological problems as advanced by Verhulst, Volterra, Lotka, Rashevsky, Kostitzin; systems theory (especially Ludwig von Bertalanffy): animal physiology, especially metabolic processes (e.g. S. Brodie et al); the nature of the biosphere (Vladimir Vernadsky, Charles Elton); animal behavior (Lorenz, Tinbergen et al); human behavior (umpteen authors). In case you wonder, this last theme relates to Holt's Law that for every regulation imposed by authority, fishermen find a behavioral response tending to nullify its intended effect – much like Newton's law that to every action there is an equal and opposite reaction. Most, if not all, of these discoveries came from browsing not in libraries but in bookshops in London and Cambridge and in other people's houses.

And, of course, I have made other 'discoveries' in recent years, such as the relevance of population genetics to problems of sustainable utilization and conservation of natural resources (Lars Witting), the beauty and utility of fractals, vibrations and chaos (Mandelbrot, The Beach Boys, Robert May et al), the Joy of Computer Simulation (my colleagues William de la Mare and Justin Cooke), and the Awe of History (my friend Mary Carmel Finley and others).[8]

So, from that limited experiential trajectory what suggestions can I offer to an assembly of librarians and information providers associated with major institutions, such as you?

[8] The history bit has found expression in my chapter "On the Notion of Sustainability" in a forthcoming book edited by David Lavigne, published by University of Limerick Press and the International Fund for Animal Welfare, on the sustainable use of wild living resources.

Perhaps, first: people are overwhelmingly important. Such institutions should position themselves to be able to facilitate personal contacts, as well as provide 'the literature': maintain open-access, continuously updated address lists. Help disadvantaged researchers be in contact with each other.

Second: bibliographic references are of course important. Current Contents (CCASF) and compilations of abstracts such as ASFA are useful. But I have found that the most useful tool for my way of working is a citation index. I think such indexes are still only available at a price – by subscription. I wish they were 'subsidized' and free. To help lateral thinking, particularly by people with limited access to bookshops and big general libraries, such indexes have to be very broad, not limited to references from a relatively small selection of periodicals. They should also include books, critical reviews of books (which often contain substantive material, including corrections of the author's mistakes) and the so-called grey literature such as submissions to conferences, workshops and symposia. However, beware the warped sense of humor of some writers. It's common knowledge that a few years ago a couple of scientists submitted a completely fake article to a primary journal that got past peer reviewers and was published. Ray Beverton and I put a fake reference in the bibliography of our book, for fun, and as far as I know no one has detected it in nearly fifty years!

Third – and related to the first and second – encourage publishers and editors of journals always to provide information about the coordinates of the authors they publish, at least at the time of going to press. And, if annotations to references are not to be provided, at least encourage authors and their editors to provide meaningful, comprehensible abstracts that will help others to decide whether they really should go to the trouble of getting hold of the paper itself. Such abstracts should be written not in the jargon of the subject, but with an eye to attracting the attention of people working outside that subject. That is, the abstract should be a vehicle for facilitating interaction across fields and disciplines.

Fourth, remember the importance of State and local archives. We are working in an area often of political and economic sensitivity, in which disinformation is rife. In recent years I have been fascinated by revelations, from the declassification of previously secret papers, concerning the international negotiations of the mid-1950s on the law of the sea and, especially, fisheries development and management, and in the 1960s concerning the future of Antarctic whaling, in both of which I was a rather innocent participant

I suppose these suggestions might look trivial to you. I could step outside my own experience and offer more general suggestions about access to information, but shall refrain now from doing so. I would end, however, by reference to a subject of great interest to me: it is the communication of science to wider publics. A few years ago I undertook to review that problem, in the field of oceanology and marine affairs, as a member of the Independent World Commission on the Ocean (IWCO), set up and chaired by Dr Mario Soares, ex-President of Portugal, but actually the brainchild of Mario Ruivo, my successor as Director of the FAO Fisheries Resources, Operations and Environment

Division. We came up with the idea of an Ocean Observatory, using that term not to refer to a building housing a telescope, but rather a system of comprehensively organized information – in our case about the sea, in all its aspects. As with the earlier notions of MAST and SAST the imagination far outstripped the means, but at least now the fantastic advances in digital technology meant that the horizon could be more clearly seen. In this connection I was excited by reading just this week about the Internet Archive and the Wayback Machine developed by Brewster Kahle, in "an attempt to achieve what the ancient Greeks and Egyptians tried at the library of Alexandria: to make a permanent record of all human knowledge" [9]. (Naturally, I have some doubts about the permanency bit, considering the piles of punch card holes and the cases of erasures and deterioration of magnetic media)

Such efforts raise important questions of, for instance, language translation, but my concern here is more the channels and ways of communication of ideas and concepts to people in other disciplines – such as lawyers, economists, engineers and artists of various species – and to administrators, politicians, media people, and the general public, too. This has always interested me, I suppose because the results of fisheries research are of little lasting interest unless they are communicated to, understood by, and enthusiastically acted upon by those who may be influential in this respect. I long ago came to the conclusion that the research scientists themselves should take some responsibility in trying to do that, though they often need help both in writing and speaking each their own language.

But constructive feedback from the audience/readership is also of great importance. In the 1990s I had an interesting experience in that regard. A small so-called Development Group of scientists (mostly mathematical biologists with a sprinkling of engineers) were charged by the IWC to come up with a new and better way of setting management rules for any future commercial whaling. They worked at this for many years, taking advantage of the prolonged pause in such whaling beginning in 1986. They triggered, I think, a minor paradigmatic revolution à la Thomas Kuhn in this field[10] that is now spreading broadly into fisheries generally.[11]

This group had to explain the new things they were doing – essentially computer simulation of the entire management process - both to other scientists in the IWC's Scientific Committee (which turned out to be more difficult than expected) and to the IWC Commissioners and members of their national delegations. This latter was not, I think, quite so difficult, except with respect to the few such Commissioners who had themselves been exposed to training in science. However, it turned out that the

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[9] Article by Betty Hodge in the *New Statesman*, 17 October 2005, p26.
[10] "The Structure of Scientific Revolutions", Second Edition, 1970. International Encyclopaedia of Unified Science, **2**(2), University of Chicago Press.
[11] See J. G. Cooke "Improvement of fishery-management advice through simulation testing of harvest algorithms" *ICES J. Mar. Sci.* **56**:797-810, 1999.

Development Group could not advance far without more precise, quantitative specification of management goals and time-frames by the Commissioners representing their governments, and, through those, the various interest groups – 'stakeholders' – in their countries.

That interactive process was difficult but eventually fruitful. The specialized scientists had to modify their language; those empowered with management had to struggle to define, quantitatively, their political and operational objectives and – this was new - a time frame for fulfilling them. All had to read materials they had previously ignored. Their archivists and documentation specialists and systems helped. And although the IWC worked formally only in English, translations were essential to true understanding. I think all of us who were engaged one way or another in this exercise learned from it.

Paciano, Revised 20 October 2005